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# NATIONAL BUREAU OF STANDARDS REPORT

6205

AN INTERIM REPORT ON BOILING TESTS
OF
INSULATIONS FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

Selden D. Cole and Paul R. Achenbach

to
Office of the Chief of Engineers
Bureau of Yards and Docks
Department of the Air Force



U. S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

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# NATIONAL BUREAU OF STANDARDS REPORT

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October 28, 1958

AN INTERIM REPORT ON BOILING TESTS OF INSULATION FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

Selden D. Cole and Paul R. Achenbach Air Conditioning, Heating, and Refrigeration Section Building Technology Division

to

Office of the Chief of Engineers Bureau of Yards and Docks Department of the Air Force IMPORTANT NOTICE

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U. S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

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#### AN INTERIM REPORT ON BOILING TESTS OF INSULATION FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

Selden D. Cole and Paul R. Achenbach

1. Introduction

As part of a research program on the characteristics required of insulations to be used in underground heat distribution systems, boiling tests were made of selected insulating materials that have been used in this application. The boiling test procedures followed those incorporated in the new specification of the Office of the Chief of Engineers dated March 24, 1958, based on the recommendations contained in Federal Construction Council Technical Report No. 30, prepared by the Building Research Advisory Board.

The test procedure requires that an 8-foot specimen of the insulation be applied to a nominal 4-inch pipe in a tank, submerged with water, and boiled for 72 hours by maintaining 125 psig steam pressure on the 4-inch pipe. After drying for 24 hours, the specimen is to be evaluated in terms of eccentricity, cracking, rupturing, swelling, fraying, material fallen from the pipe, and separation of the joints.

# 2. Specimens Tested

Five materials have been subjected to this boiling test: Kaylo, Thermobestos, Unibestos, Foam-Sil, and Fiberglas, Some have been tested more than once and Fiberglas has been tested in blanket, loose fill, and premolded forms. Loose fill Fiberglas has also been boiled for 72 hours inside a clay tile conduit system. Some experimentation has been conducted on methods for covering the insulating material and for securing it on the pipe. The specimens that have been tested are summarized in the following table.

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pipe. The apparament that have been touted are summarized in
the following table.

### Discussion SPECIMEN IDENTIFICATION

SPECIMEN	I NAME	THICKNESS	HOURS OF BOILING
1 1	Molded fiberglas,	1 in.	72
	Standard Standard	red by some mener	
12 100	Kaylo Mas application	ad in in.	5 m. 72 m.
3	Foam-Sil	3 in. 1081 at	72
4	Foam-Sil Unibestos	1.5 in.	12 2 2 2 2 1 4 1 4 1 4 1 1 1 1 1 1 1 1 1
5	Fiberglas-Ric-Wil	1.5 in.	12 + 12 40
6	Fiberglas-1/4 mesh,	1.5 in.	72
	loose fill Thermobestos		
7	Thermobestos	1.5 in.	72
8	Thermobestos Molded fiberglas,	01.5 in. 0 and 0	48 + 72
	Low Temperature		
9	Molded fiberglas,	1.5 in.	72
	Low Temperature		
10	Foam-Silver Area and a second	1.5 in.	72 + 72
11	Thermobestos	1.5 in.	72 + 72
12	Fiberglas-1/4 mesh,	1.5 in.	72
	loose fill		
13	Fiberglas-16 mesh,	1.5 in.	72
THE REPORT OF THE PARTY OF THE	loose fill as is a loos		
14	bol Kaylo plaging shrees und	1.5 in.	72 + 72
15	Molded fiberglas,	1.5 in	72 + 72
	Standard The Standard		
16	Fiberglas-Stillwater,	1.7 in. min.	72
	Conduit - loose fill		
	ation fell off the pipe in		
	SUCCESSION DESIGN AND SECTOR		

Calbertour Dead on the require of one test only, it appears
that this meteodal will remain on the pipe for it know
under builing confictency with approximate aparties of
cloughing off of the outer layers. The birder is
located out, leaving the outer surface act and specdo ordinated to its lard character show now, incre
appoint to be no scalling of the material. It where

#### PROTESTED INSTITUTE

LOS SO ESTOS	MATCHINES I in.	MAME Rolded fiberglass Standard	SPROIMEN
97 97 97 97 + 97	1 in. 3 in. 1.5 in. 1.5 in.	Maylo Mode-Sil Unibactos Microlas-Nic-Wil Microlas-Lican,	000000000000000000000000000000000000000
	1.5 in. 1.5 in.	Lift eacof conscionants and the second solution for Temperature and the second solution	2
ST + ST FS + TS	1.5 in.	Low Temperature From-Sil Thermobeatos Fibergias-1/A moch, loose fill	ol II
72 72 + 72	1.5 10.	Fiberglas-15 mesh, loose fill Maylo	11
27 + 27 27 - 41	1.5 in.	Holded fizergies. Standard Fiberelas-Stalustes. Contato - loose fill	97

# 3. Discussion and Conclusions

The conclusions drawn regarding the effect of boiling on five types of insulation, as indicated by the results of the tests, are summarized below, followed by some general conclusions regarding the application of insulations to underground piping. These conclusions are based on the test results summarized in Section 4 of this report. The results in successive tests of the same material were not always consistent. Thus, a more comprehensive study might lead to some modifications in the conclusions.

Effect of Boiling on Five Types of Insulation

- Kaylo: This insulation will probably withstand 72 hours or more of boiling without falling off the pipe or being cut into pieces if straps are used to secure it to the pipe. Appreciable erosion occurs at the joints in 3 to 6 days of boiling, such that a gap of an inch or more may develop at the joints.
- Thermobestos: This insulation appears to swell some during boiling, placing straps under tension. Light gage aluminum straps were sheared at the eye on this material. Longitudinal joints tend to open a little during boiling, perhaps due to swelling, and a slight erosion occurred at the joints. In one test, none of the insulation fell off the pipe in 72 hours, when supported by straps or wires. In a second test, three sections in succession broke and each fell off within 72 hours, using straps for support in each case.
- Unibestos: Based on the results of one test only, it appears that this material will remain on the pipe for 72 hours, under boiling conditions, with appreciable spalling or sloughing off of the outer layers. The binder is leached out, leaving the outer surface soft and spongy as contrasted to its hard character when new. There appears to be no swelling of the material. It adheres to the pipe after boiling.

# Macusalon and Conclusions

Pos

ine conditions drawn reserving the effect of heiling on five types of insulation, as inducted by the results of the factor, as inducted by the results of the court are summarized below. Followed by some consistent constitutions are based on the test results and matter in Section 4 of this report. The results in such assets to the same bear of the same according to this report. The results in such assets to the same completent, Thus a note comprehensive attain the constitution in the constitutions as

# motistized to sequit ovin no satisfe to toois

Maylo: Sale issulation will probably attached 72 bours or more of boilting without falling off she pipe or being out into pieces if strange are used to neo,we it to the pipe. Approphable exceton courts at the joints in 3 to pipe. Approphable exceton courts at the joints in 3 to days of boiling, such that a gap or an inch or more may develop at the joints.

Therecoeston: This insulation appears to seel some during boiling, placing straps under temeron. Light gade alusting at mag straps were cheared at the eye on this metaring boil-longitudinal joints tend to open a little during boil-ling, parkeys due to swalling, and a clicht crosten occurred at the joints. In one test, none of the insulation fall off the tipe in 72 hours, when supported by attached by attached or wires. In a second test, shape sections in auccession broke and each fell off within 72 hours, waing succession broke and each case, when 72 hours, waing attached to strape to support in each case.

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slowphing off of the outer layers, The binders is
leached out, leaving the outer surface soft and spongy
as contrasted to its hard character show new. There
appears to be no sealling of the material, it scheres
to the pipe after poiling.

Form-iil: The Poun-Sil material itself door not appear to be afrected by boiling water. There is virtually no eresion or other loss of suberial. The come who be seal the lavery together in manufacture As walkened in 144 hours of boiling and some sections totals be pulled apart by hand, although none care again during the 144-hour boiling test. It is a britise, irault material and can be out by the support in allagant. section becomes lightly loose on the rise and start to vibrate as a result of the bolling action. Dinding the material too tightly to the plue may cause it to erack when the pipe communds. The is a closed-coll insulation which limits the access of rater to the steam pipe some that under flooded conditions.

Fiberglau: This saterial has been subjected to nothing unterunder the following conditions and in the following forms:

- Loose fill supported on a pipe with 1/4-inch nareware cloth.
- b. loose fill supported on a pine auch li-ment wire Joreen.
  - Loose Fill in the Stillwater Clay Fromusts conduit.
  - d.
  - Molded 1" thick supported by strops and wires. Molded 1-1/2" thick supported by strops and wires. e.
- Î. Folded 1-1/2" thick supported by 16-arch screen,
  - Blanket wrop 1-1/2" thick, Ric-Wil, supported by 8. plastic mach.

In all forms of Tiberglas, the boiling mater added leaching action in the place fibers which weapens them and causes then to break into short pieces. This action progresses more rapidly near the pipe than it greater distances. At the end of 72 hours of boiling, an approclable amount of the material near the pipe appears to the naked age to be pulveriled to a consistency of dust, but a alcrescopic examination shows that it still has a fibrous character although there is a tageled appearance to the libers. Comewhat farther out from the pipe, the individual fibers are covered with bunnilmont bis ters or even clusters of such biliters. The nature of the a blisters is not known unless it is the products of the leaching action of water on the glass.

La Company of the Com 2 Million William to the state of the interthe lifetime builting news, to be a writing soul-life and and the second control of the company of the second of the ... to the process of the specific of the true of the state of the THE RELEASE WAS A CAST BUTTON OF BUTTON and the second to the second state of the second se . I IT IN A CAROLT TENT CONCRETE CONCRETE AND ALL OF THE CONCRETE CONCRE , ಆರ್. ೨೮೫ ಅಲ್ಲೂಕ್ ಆರ್. ಕಾಲ್ಡ್ ಚಾರ್ಟ್ಗಳು ಚಿತ್ರ . min and color will become lotte THE RESIDENCE OF THE PROPERTY a valuation to the plant to the plant with a second to the first terms of the second to the second t and the second district weeking some a self of one is The production of the control of the a en la compositio de la compansión de la compansión de la composition della composi Literatura (n. 1880). Santa Santa (n. 1884). Santa (n. 1884). THE RESERVE AND THE PROPERTY OF A STREET OF THE PROPERTY OF TH the factor and a few and the factor of the few and the . TENE . OTH IN THE TO BE The effectiveness of the material as an insulation doe not appear to be greatly reduced by boiling as lone as the insulation remains on the pipe in its original thickness and without voids.

Prolonged boiling of the insulation in a tank appears to progressively break up the fibers and eventually substantial amounts of the material are lost by falling into the bottom of the tank. The rate at which this loss occurs, appears to be related to the uniformity of packing the fibers, the density of the pack, whother or not a binder us used, and the size of openings in the covering material. Generally apeaking, a factory-made insulation envelope consisting of compressed blankets of Piberglas will not deteriorate as rapidly as loose fill material applied to the pipe by hand. Insulation, supped in a 16-mesh plastic or metal screen, will not be lost as rapidly as the same material screen, will not be lost as rapidly as the same material screen.

Factory-made envelopes using blanket Fiberglas insulation, as made by the Ric-Wil Company, premolded Fiberglas 1-1/2 inches thick and wrapped with 16-mesh screen, and premolded Fiberglas 1-1/2 inches thick, secured with steel bunds at 1-root intervals, will all withstand 72 hours of boiling without appreciable loss of material. Loose fill interglas hand packed to a censity of 7-1/2 pounds will suffer appreciable loss in 72 hours boiling with either 16-mesh or 1/4-inch mesh wrapper. The factory-made blanket envelope and the premolded envelope wrapped in aire mesh both suffer noticeable loss of material after boiling 144 hours whereas, a section of the premolded material, supported by streps, fell off the pipe during 144 hours of butting.

Poiling loose fill Fiberglas insulation inside a clay tile conduit system of the type manufactured by the fillmater Clay Products Company resulted in the loss of an appreciable amount of material within 3 feet of the vent pipe at one and, and very little loss in the remainder of the test species a during a 7-hour boiling period. The vent pipes were attached to the conduit at the top of the arch tile. The insulation was packed to a sonsity of 5.5 lb/cu ft.

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the fact that is instructed referenced by around gift to the state of the s of the gradual and the open to a transfer of the state of form and the first of a construction position with a second construction. and the state of the state of the transfer of the state o of color and lo price In a typical installation, such a system would probably be vented from the side blocks instead of at the top of the arch. In this case, the steam would leave the insulation savity through the upper holes of each of the ventilated side blocks and the water level would be at about this same height. The presence of a steam space in the upper part of the arch tile would probably reduce the mechanical aritation within the insulation as compared to that when the conduit was completely filled with water. By using 16-mesh screen over the openings in the side block, the loss of material at these openings could be reduced. It is probable that a solid enclosure for loose fill insulation, such as that used in the clay tile system, would prevent loss of fibrous material suring a boiling period of 72 hours as freet-ively as a screen mesh wrapper in the boiling tank, if not more so.

On the other hand, it is also probable that prolonged bolling of Fiberglas insulation over a period of many days in a clay tile system would seriously deteriorate the insulation, so such a system should not be used where frequent flooding sould occur.

#### General Conclusions

Wire bands should not be used to secure insulation on gap underground.

traps should not be made of light-gars metal. Espain lon of the insulation can cause the eyes to cut light-gars strate.

Molded insulation should fit the pipes and ly. force were tions of insulation will often vibrate on the pipe during busing and cause the straps to cut the insulation into piccos.

Prittle materials should not be strugged to tightly that pipe expansion will put tendion on the insulation.

Except for the cellular class, the boiling enter fill cause some crosion at the ion studing joints and the butt joint between adjacent lengths. It all also erose channels or holes through the body of ribrous in mulations.

Complete trappers of vire much or suitable platic much (16-meth or smaller) will probably minimize spelling and cloudsing off of insulation on an underground place more effectively than straps under boiling equalities.

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percentage of the second second second

The boiling tests and thus far indicate that all five of the materials tests will probably determine all niffeabily if boiling continues indefinitely. Tous-fill all probably the least affected by boiling, but the fit of the material on the pipe may determine the likelihood of cracking the insulation or its tendency to vibrate on the pipe.

The deleterious effect of bolling siter on most insulating material now used for underground piping systems, as revealed by these tests, emphasized the new for continuous effort to design such systems so they will function many years serve water gains access to the insulation, no matter that the narroof the terrain.

# 4. Test Results

The results observed during each bolling to the acceptance of the managery results of the recommendation, the nethod of application, the condition of the bolling to t, and one or more photographs of each application.



#### BOILING TEST OF PIPE INSULATION

#### Specimen 1

# Description of Material

Manufacturer: Owens-Corning Figerslas Company

Identification name or symbol: Pre-molded Fiberglas Pr. Standard

Binder used: Organic thermosetting resin

Length of section: 3 ft

Thickness of insulation: 1 in.

Covering: Light cloth fabric

Pipe diameter: 4 in.

# Method of Application

Method of fastening: 1st section - Four 3/4-in. straps,

1 ft apart

2nd section - Four No. 12 copper wires,

1 ft apart

Position of joints: 1st section - Joints vertical

2nd section - Joints horizontal

Covering used: Light cloth fabric

Other features: Fourth strap on 1st section covered lapped

fabric at joint between sections



#### Test Results

Amount fallen from pipe: Top half of 1st section fell off.

Bottom half dropped down and resting

on straps. 2nd section intact.

Eccentricity: None on 2nd section

Separation at joints: None on 2nd section

Cracks and ruptures: None on 2nd section

Fraying: None

Swelling: Slight swelling on 2nd section

Erosion: Some erosion on interior surface and at joints

Other damage: None

Moisture retention: Not measured

Reference to photographs: Fig 1 shows initial appearance; right specimen.

Fig 3 shows 1st section gone after 72 hours; right specimen.

Swelled appearance of 2nd section is primarily the stretched fabric covering.

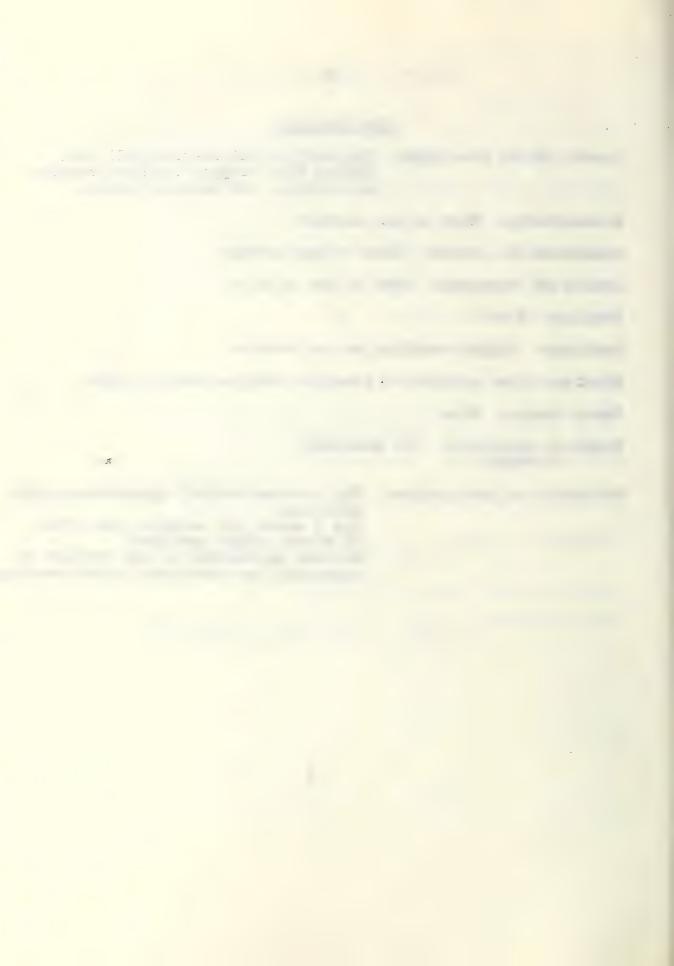




Figure 1



Figure 3

#### BOILING TEST OF PIPE INSULATION

#### Specimen 2

# Description of Material

Manufacturer: Owens-Corning Filor las dometry

Identification name or symbol: Kaylo - bre-moldes calcin

silicate and ashestos fibers

Binder used: Calcium silicate

Length of section: 3 ft

Thickness of insulation: 1 in.

Covering: Light cloth fabric

Pipe diameter: 4 in.

# Method of Application

1st section - Four 3/4-in. straps, 1 15 apart 2nd section - Four No. 12 copper wires, Method of fastening:

1 ft apart

1st section - joints vertical Position of joints:

2nd section - Joints horizontal

Covering used: Light cloth fabric

Other features: Fourth strap on 1st section covered lapped

fabric at joint between sections

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# Test Results

Amount fallen from pipe: Farts 3 am section. 15 1 3:

Secentricity: None.

Separation at joints: None

Cracks and reptures: Insulation out of miles on 2nd of wind

and broken into pieces. Top half of 2nd section dislocated. See Fig 3: left

specimen.

Fraying: None

Swelling: None

Erosion: Some erosion at joints

Other damage: Cloth Jahrio torn on and associon

Moisture retention: Not measured

Reference to photographs: Fig 1 shows initial appearance;

left specimen.

Fig 3 shows rupture of 2nd section as it appeared after 72 hr of boiling; left specimen.

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#### ECILING TEST OF PIPE INSULATION

### Specimen 3

# secription of interial

Mandaevurer: Fitts of h Jorning Company

Iventification name or symbol: Jose-Wil. Fro-Muldo. Joseph cell slass foam.

Timber sect bare. Times material. Each piece was or two layers semented as ether innocentally.

Length of sections 17 in.

Thickness of insulation: 3 in.

Covering: None

Pipe diameter: 4 in.

# ether of application

Fether of Tastenine: lat and and suctions - The 3 days. 2 in. from ends.

3rd section - One strap and one wire,
2 in. from ends.

4th and 5th sections - Two Mo. 12

wires, 2 in. from ends.

Forition of grints: loc, 3rd, 5th restions - older or rest

Covering used: Hone

Other features: None



# Test homeles

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constitute of the strong out projects. For the many in the strong of the

Separation at joints: None

Crack and reported: Protection of the bestion of the continuous states of the continuous states of the continuous states and the continuous states of the continuous states

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Laglling: Bone

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aforeme to photographs: The a bhows into it when the

Fig 4 shows appearance after 72 hr





Figure 2



Figure 4

#### FORLING TEST OF FEE LAND TIGHT

# openimen 4

# 

Manufacturer: Winn - sees on and I have the pung

lunntification norm of symbols initiation. 3-- idea in it.

Binder uzed: Silicate

Length of section: 3 ft

Thiomeso of insulation: 1 1/2 in.

Covering: None. interior nurses made quite has with dinger material.

Pipe diameter: 4 in.

# Bethod of application

Wethou of fastening: is section - rour 3/2-in. strops, i it spart

included ion - rour or is copper wires,

I it apart

Position of points: 1st section - joints harizontal and section - joints vertical

Other featurest Hone

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Reference to photographs: The schools initial application

right specimen.

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Comments: Buth worthous acheres to the paper at the ent the test. A araper had to be used to loosen the

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#### DOTLING TEST OF PIPE INSULATION

#### Onecimon 5

# Description of Material

Manufacturer: Rie-Wil - Sectional Pibergla: Vice Insulation

Identification name or symbol: - Dianet Tooygla: 45 day:

Ly Rie-Wil.

Einder used: Fibergias biled treatment unity

Length of section: 2 ft with overlapping serem joints

Thickness of insulation: 1-1/ inches - 7-1/2 lbs density

Covering: 14 x 16 mesh fiber las strangs plastic costs.

Pipe diameter: 4 in.

# aethed of Application

Method of fastening: Tropared sections slipped on pipe Position of joints: Only buts joints in this construction Covering used: Fiberglas screen held with metal staples. Other features: 2 in. Jup of covering at butt joints.

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# Test Results

Amount fallen from pipe: Slight loss after 72 hr.

Eccentricity: Slight

Separation at joints: None after 72 hrs - open after 144

Cracks and ruptures: None after 72 hrs.

Fraying: Mone

Swelling: None after 72 hrs.

Erosion: Slight after 72 hrs.

Other damage: Plastic covering brittle after 144 hrs.

Moisture retention (percent): Dry

Reference to photographs: Fig 5 - after 72 hrs boiling
Fig 5 - buttjoint uncovered to show

negligible loss of wool

Fig 7 - after 144 hrs boiling shows some loss of Fiberglas wool

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Figure 6





Figure 7



#### BOILING TEST OF PIPE INSULATION

# Specimen 6

# Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Loose-rill lier las

Binder used: None

Length of section: 7'-2"

Thickness of insulation: 1.5 ln.

Covering: 1/4 in. mesh gaivanized hardware cloth used to retain loose fill insulation on pipe

Pipe diameter: 4 in.

#### Method of Application

Method of fastening:

spread as evenly as possible on a flat piece of 1/4 in, most hardware cloth and held in place with big stitches of cotton string. See Fig 8 and 9. Even though the insulation was spread as evenly as possible, there was an appearance of clumps in the layer and protable variations in density. The stath of the most wrapper and the amount of insulation used was such that the insulation would be compressed to a density of 71b/ou it and a thirdness of 1-1/2 in, when stapped around the size with the sire mesh overlapping one inch at the edges. The wire mesh wrapper was held in place with 3/4 in, bands spaced 12 in, apart.

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Length of sections 72-2".

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#### Test Results

Amount fallen from pipe: about 30 percent as weighed dry before and after boiling

Other damage: 4 in. pipe exposed in many places as voids appeared in an irregular pattern in the insulation

Reference to photographs: Fig 8, left specimen, shows appearance after 72 hrs boiling
Fig 9 shows close-up view of voids in the insulation

# Internal Section

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Figure 9



#### BOILING TEST OF PIPE INSULATION

#### Specimen 7

# Description of Material

Manufacturer: Johns-Manville

Identification name or symbol: Thermobestos

Binder used: A calcium silicate product with an entone Albert

Length of section: 36 in.

Thickness of insulation: 1-1/2 in.

Covering: None

Pipe diameter: 4 in.

#### Method of Application

Method of Castening: 1st section - 4 straps

and section - -12 copper mare

3rd section - strapped

Position of joints: lot Jestion - Joints horizontal

2nd section - Joints vertical 3rd section - Joints horizontal

Covering used: None

Other features: 3rd section - and about 15 in, long.

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# Test in all :

Amount fallen from pipe: None

Eccentricity: None

Slight, except short piece .hich opened up so that pipe was exposed. Separation at joints:

Cracks and ruptures: None

Fraying: None

Swelling: None

Erosion: light outside edge of all joints

Wire out into insulation a distance smal to it: Other damage:

diameter in some places

Reference to photographs: Pir 8. right specimen, whoma appearance after 72 hrs boiling. Note oll ht

separation of longitudinal joint and plight embedment of wire at farther end

of the middle section

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#### BOILING TEST OF PIPE INSULATION

#### Specimen 8

# Description of Laterial

Manufacturer: Owens-Corning Fiberglas

Identification name or symbol: ireformed 1.5 in. Fibergias (low temperature)

Binder used: Organic thermosetting resin

Length of section: 7 ft - 1 in.

Thickness of insulation: 1.5 In.

Covering: Vapor barrier paper removed from original product. Manual galvanized screen wrapper applied in the laboratory.

Pipe diameter: 4 in.

#### Method of application

Method of fastening: 16 mesh galvanized wire fastened every 2 in. at the longitudinal joint with 22 copper like

Position of joints: lst section - Joints horizontal 2nd section - Joints vertical 3rd section - Joints horizontal

Other features: Wire mesh wrapper in one piece with 1 in. lapped seam.

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# Test Tabulto

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: Only slightly at butt joints after 120 hrs.

Cracks and ruptures: None alter 45 hrs.

Fraying: None after 48 hrs.

Swelling: None

Erosion: None after 48 hrs. Clicht erosion at buttjoints after 120 hrs.

Other damage: No damage that could be observed after 72 hrs. Except for the slight erosion at the joints and the usual embrittlement of the plass fibers, this specimen was in good condition after 120 hrs of boiling.

Moisture retention (percent): Not measured

Reference to photographs: Fig 10 is a view of the specimen after 120 hrs of boiling.

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Figure 10



#### BOILING TEST OF PIPE INSULATION

#### Specimen 9

# Description of Material

Manufacturer: Owens-Corning Piberglas Company

Identification name or symbol: Freformed 1.5 in, Fiberglas (10% temperature)

Pinder used: Organic thormosetting resin

Length of section: 3 ft

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

# Method of Application

1.t section - 4-3/4 in. strups Method of fastening:

and section - 4- 12 copper alre

3rd section - 2-#12 copper wire

1st section - Joints vertical Position of joints:

2nd section - Joints horizontal 3rd section - 45°

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#### Test Results

Amount fallen from pipe: None as pieces

Eccentricity: Insulation layers flared out at seams

Separation at joints: Joints opened from 1/8 in. to more than 1 in.

Cracks and ruptures: No cracks or complete ruptures but surface cut by wires

Fraying: All joints showed fraying. Fraying more extensive on second section with joints located horizontally. Lee it ll

Swelling: Slight

Erosion: All seams showed erosion with delamination evident

Other damage: Wires cut into insulation. See Fig 12

Moisture retention (percent): Not measured

Reference to photographs: Fig 11 shows appearance after 72 hrs boil-

Fig 12 shows closeup of sections and 3 fastened with wires. Mirrored view of second section shows nature of the fraying and delamination at the horizontal joint

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#### BOILING TEST OF FIRE IN ULATION

#### Specimen 10

#### Description of Atorial

Manufacturer: Pittsburgh Corning Glass Company

Identification name or symbol: Fram-III - - cellular silicate

Binder used: 99 + % pure silica

Length of section: 17 in.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

#### Method of application

Method of fastening: With clamps screw thread tightened

Position of Joints: 1st section - Joints horisontal

2nd section - Joints vertical

3rd section - 45°

4th section - Joints horizontal 5th section - Joints vertical

Covering used: None

Other features: All joints tight to slight or white

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#### Test Results

amount fallen from pipe: None

Eccentricity: None

Separation at joints: Slightly at butt joints

Cracks and ruptures: About half of the individual pieces cracked circumferentially when steam was first turned on.

No additional cracks developed during the test.

Fraying: None

Swelling: None

Erosion: Some of the cement used in fabrication of sections disappeared but not to point of unscaling joints after 144 hrs.

Other damage: Sections cracked on initial heating but cracks had not changed after 144 hrs. Cracks may have been caused by tight banding and pipe expansion on heating.

Moisture retention (percent): None

Reference to photographs: Fig 13 shows appearance of Foam-311 after 72 hrs boiling

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Figure lj



#### BOILING TEST OF PIPE INSULATION

#### Specimen 11

#### Description of Nuterial

Manufacturer: Johan-Manville Congany

Identification name or symbol: Thermobestos, Fromolded Calcium silicate and asbestos fibers

Binder used: Calcium silicate

Length of sections: 36 in.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

#### Method of application

Method of fastening: lit section - Pour 3/4 in. atmos of aluminum

the longitudinal joint. Two metal strups added after 72 hrs because plactic mesh had

stretched.

Position of joints: 1st section - Joints horizontal

2nd section - Joints vertical

Covering used: None except filerglas mesh on second section

Other features: Aluminum strups replaced with steel strups after

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#### Tout Febults

Amount fallen from pipe: lat section fell off in less than 14 hr then aluminum strars shoursi. lut section replaced and steel straps used. lat section off again after 48 hours boiling. Toplaced and boiled for an additional 72 hours with one place breaking off.

Cracks and ruptures: it 72 hours, seams of mesh-covered sections had opened about 2 in. 2 strupt were added to the second section and after 72 hours of additional boiling, the seam opening had not increased in the second section but had in the short unstrupped section.

Other damage: Some erosion at joints after 144 hours of boiling.

Moisture retention (percent): Not measured

Reference to photographs: Fig. 14 shows condition of mesh-covered section after 144 hours of bolling.

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Figure Lu



#### EOILING TEST OF PIPE INSULATION

#### Specimen 12

#### Description of Naterial

Manufacturer: Oven:-Corning liber les Samany

identification name or symbol: Loose fill Fibergla 1001

Binder used: None

Length of section: 7 ft - h in.

Thickness of injulation: 1.5 in.

Covering: 1/4 in, mesh calvanized hardware cloth to retain look fill insulation on pipe

Pipe diameter: 4 in.

#### Methol of Application

Method of fastening: A weighed amount of loose fill diberglas was spread as evenly as possible on a flat piece of 1/4 in, mosh hardware cloth and held in place with big stitches of cotton string. See Fig 15 and 16. Even though the in ulution was apread as evenly as possible, there was an appearance of clume in the layer and probably variation; in density. The wieth of the me h propper and the amount of in ulation used was such that the insulation would be donpresuod to a density of 7 lb/eu ft and a thickness of 1-1/2 in. when supped around the pipe with the the mech overlapping one inch it the edges. The sire meth suppor was hold in place with 3/4 in, bands spaced 12 in, apart.

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#### Tost Posults

Amount fallen from pipe: About 20 percent as seighed dry before and after boiling.

Other damage: Pipe exposed in many places as void in an irregular pattern formed in the insulation.

Moisture retention (percent): None

Reference to photographs: Fig 15, left specimen, shows appearance after 72 hours boiling Fig 16, lettem specimen, shows closeup of voids with a mirror image of the undermeath portion.

Microscopic Examinations of insulations simples of insulation were taken from the specimen at leveral locations after the test for microscopic examination. Increphotographs were taken of the glass fibers before and after boiling. Fig los shows the smooth, transparent, cylindrical appearance of the fibers when new. Fig los shows the appearance of the material near the surface of the envelope after boiling. It was broken into many short pieces, and appeared brown to the maked eye (perhaps the effect of the boiling water and steam on the oil treatment of the original material). Fig los and los are about 400 to 1 magnifications.

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Figure 15





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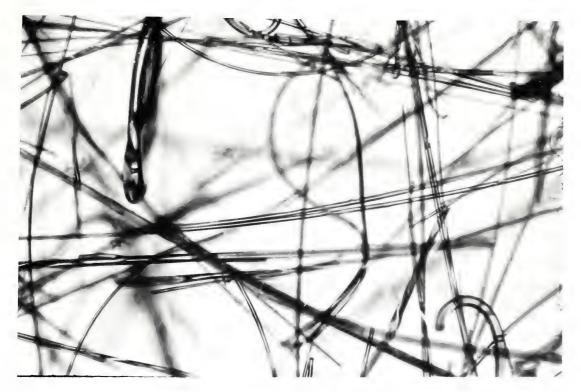


Figure 16a



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#### EOILING TEST OF PIPE INSULATION

#### Specimen 13

#### Description of Natorial

Manufacturer: Asons-Comming Pibergios Company

identification have or symbol: loose fill apor he wool

Binder used: None

Length of section: 7 ft - 2 in.

Thickness of insulation: 1.5 in.

Covering: 16-mesh gulvaninep screen wire use to nearly look ....

Pipe diameter: 4 in.

#### Method of Application

Method of Fastening:

spread evenly on a flat place of 16-7 h glvaniant offern wire and held in place
by stitches of cotton string. Ven them is
insulation was appearance of classes in the layer
and probable variations in density. The dots
of the screen wrapper and the abount of insulation
used was such that the insulation would
comproded to a density of 7 lb/ou t and
thickness of 1-1/2 in. Her proped around the
pipe with the size mesh overlaying two in.
the cases. The screen rapper a hold in pith 3/4 in. here or pages in.
Fig 13.

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#### Test Results

Amount fallen from pipe: about 10 percent of place sool as weighted dry before and arter boiling.

Other damage: Pipe exposed at several small spots and some local log of fibrous material

Reference to photographs: Fig.

Fig 15, right specimen, thous appearance after 72 hours boiling
Fig 16, top specimen, thems one spot there
pipe exposed. 15-much screen airc provides a sort of fluxible supplies that
tenied to bulge slightly between straps

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#### BOILING TEST OF PIPE INSULATION

#### Specimen 14

#### Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Kaylo

Binder used: Silicate

Length of section: 3 ft

Thickness of insulation: 1-1/2 in.

Covering: Canvas on 1st and short sections

Pipe diameter: 4 in.

#### Methor of application

Method of fastening: 3/4 pipe strups spaced Lz in, apart

lst section - Joints horizontal 2nd section - Joints vertical Position of joints:

3rd section - Joints horizontal

Covering used: Canvas on lat section and short section

Other features: Longitudinal joints did not close by 1/3 in. when insulation was tightly fitted to the 4 in. pipe.

Insulation cavity was a little too small in diameter.

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Covering used: Canvas on 1 t seation and obert abtion

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#### Test Results

Amount fallen from pipe: None after 72 hours

Eccentricity: None

Separation at joints: All joints opened up about 3/4 in. Insulation moved slightly on 4 in. pipe

Cracks and ruptures: None

Fraying: None

Erosion: Edges of vertical joints eroded so that circumference of two half sections lost about 1 in. after 144 hours boiling.

Reference to photographs: Fig 17 shows appearance after 72 hours boiling

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#### BOILING TEST OF PIPE INSULATION

#### Specimen 15

#### Description of Material

Manufacturer: Owens-Corning Piberglas Company

Identification name or symbol: Fremolied them in , tan ware

Binder Wsed: Fhenolic

Length of section: 3 ft.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

#### Method of Application

lat section, 4 straps - 72 hrs + 72 hrs. Method of fautening:

2nd section, 4 copper wires - 72 hrs - new

section, 4 straps 72 hrs.

3rd section, 2 straps - 72 hrs + 72 hrs

Position of joints: lat section - Joints vertical

and section - Joints horizontal 3rd section - Joints vertical

Other features: None

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#### Test Mesults

Amount fallen from pipe:

After 72 hrs.

lst section, none.

and section, top half off pipe, part of bottom half hunging by wires. Replaced with a new length.

3rd section, none

Separation at joints:

1st and 3rd sections tight at longitudinal joints, End section not on pipe so no butt joints.

Cracks and ruptures: None

Fraying: Very slight fraying at all joints.

Swelling: Very slight

Erosion: Butt joint end eroded to a concave shape on sections 1 and 3. Longitudinal joints eroded slightly at surface.

Other damage: After 144 hrs; lat section; right side off pipe;

part of left side hanging at bottom by straps.
After 72 hrs; replaced 2nd section; joints tight;

joints show slight erosion at survace.

After 144 hru; 3rd section; longitudinal joint

tight.

Reference to photographs:

Fig 13 shows the appearance of the insulation after 72 hours boiling. The first section, secured with straps, shows slight erosion and fraying. The second section, secured with wires, had separated from the pipe and a part had fallen into the bottom of the tank.

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Figure 15

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## Specimen 16

### FOLLAND TEST OF LOOSE FILL FIBEROLS IN TULNATUR CLAY PRODUCTS CLAY-1-EAR Y TUN

## Description of Test Specimen

Ioose fill Fibergla. insulation, manufactures by Osens-Corning Fiberglas Company, was boiled inside a 14-ft test specimen of the Cort-a-Bar Clay Tile Consult as manufactures by the Still-water Clay Projects Company. The insulation was packed to an average density of 5.5 lb/cu ft around a 4-inch pipe over a z-inch pipe, both located inside a clay tile conduit made of 5-inch high side blocks and 8-inch semi-cylingrical arch tile.

The thickness of the insulation varies from a minimum of about 1.72 inches around the top half of the 4-inch pipe to a suxurum of approximately 4.75 inches at some places underneath the 4-inch pipe.

The insulation had been subjected, during carlier to t, co several lengthy heating and cooling cycles, and to numerous setting and drying cycles without boiling the insulation. The insulation had a semi-rigid molded characteristic before the boiling to t and the fibers were brittle and broken into short pieces near the pipe.

## Boiling Procedure

The ends of the systam tero scales so it could be filled with water. The mater level as indicates by an external si ht class and makeup mater was added to replace that evaporates to maintain the water level at the top of the inculation space, steam as introduced into the 4-inch pipe at a pressure of 15 paig and the pressure was maintained for 72 hours. The steam generated include the conduit was vented to the atmosphere through the vertical 2 x 3-inch ducts placed, one at such one of the test specimen, at the top of the cylindrical arch talk forming the top of the conduit. The vertical leg of the two vents and about 4 feet long.

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## Test Results

Fig 19 shows the appearance of the insulation in the conduit after boiling 72 hours. The dark streak at top center is a copper tube used at one time to introduce water to the insulation.

Fig 20 shows the appearance, at the downstream end, of the insulation. The 4 in. pipe is exposed for about 1/2 of its circumference on the lower side. There was considerable loss of insulation only near the outlet end for a distance of about 3 ft. A small amount was also lost at the inlet end. Apparently the insulation was carried out of the vertical vent pipes by the surging water and steam. Some pulverized glass fibers were found in the vent pipe at the end of the test. Except for the loss indicated above, there was little evidence of any voids in the remainder of the insulation.

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Figure 19





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#### U. S. DEPARTMENT OF COMMERCE

Sinclair Weeks, Secretary

#### NATIONAL BUREAU OF STANDARDS

A. V. Astin, Director



#### THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

#### WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics, Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

Office of Basic Instrumentation.

# · Office of Weights and Measures.

#### BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Tonospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio Meteorology.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

